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NSSDC NATIONAL SPACE SCIENCE DATA CENTER

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A COMMUNICATIONS MODEL FOR THE ISTP CORRELATIVE DATA ANALYSIS NETWORK

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JANUARY 1987
NSSDC TECHNICAL REPORT

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I. INTRODUCTION

The International Solar Terrestrial Physics (ISTP) program is an ambitious space exploration program involving spacecraft built and managed by three international agencies: NASA, ESA, and ISAS. The ISTP program is a major new space science initiative to study the energetics of the near Earth space environment (or geospace) with instruments on a set of integrated and coordinated spacecraft flight missions. The intent of the program is to mobilize a worldwide scientific community in a coordinated study of Sun-Earth plasma interactions, solar and heliospheric physics, and global geospace physics, in addition to extending our current knowledge of basic space plasma physics.

Modern computer-to-computer electronic networks are already being employed to facilitate international collaborative data exchange and analysis. Even before the ISTP spacecraft are launched, direct electronic links can greatly facilitate rapid communication among the various ISTP experimental groups and project offices in all countries in the joint development and checkout of flight hardware. More important, with the breadth of interests and the multitude of scientists involved in a project like ISTP, easy collaborative and correlative analysis of data from multiple instruments and spacecraft is the key to achieving the scientific goals on which the project has been founded. That analysis requires the existence of a capable network.

The Space Physics and Analysis Network (SPAN) was implemented and funded by NASA to support exactly the kinds of science that will be central to the ISTP project (see Green et. al, 1983). SPAN has not been sized or designed in itself, however, to support the volume of traffic or other requirements associated with a collaborative flight project of the scope of ISTP. But a project-oriented network could be overlaid on the existing SPAN network that can meet project requirements and would yet take the maximum advantage of the existing communications structure. An ISTP network created in this fashion would be fully interconnected with existing SPAN capabilities, would utilize the management structure and experience associated with SPAN a fully functional backup system. At the same time, at minimum cost and with full project control, the ISTP project would obtain a network dedicated to ISTP requirements.

The purpose of this document is to propose a cost effect computer network to support ISTP correlative data analysis. The proposed system makes the most of the existing NASA of communications infrastructure and remote institution hardware and software. In addition, the configuration is based heavily on the experience gained from years of trial and error in the gradual implementation of NASA's only correlative science network, SPAN.

II. BACKGROUND OF SPAN

The National Space Science Data Center (NSSDC) is responsible for the development and management of the Space Physics Analysis Network or SPAN (see Green, 1984, Green and Peters, 1985). SPAN was designed in 1980 and started operation in 1981 as a pilot project with three nodes. Today SPAN is a wide area network that connects over 600 computers in the United States and in Europe. SPAN's development and growth has largely been within the space plasma physics community. A large science user working group provides the major direction for SPAN's growth (see Baker et. al., 1984, Green et. al., 1984 and 1985, Green and Zwickl, 1985 and Greenstadt and Green, 1981).

Over the years SPAN has rapidly evolved into an international network which has successfully demonstrated its ability to support major spacecraft missions including encounter operations. During the ICE encounter with comet Giacobini-Zinner, SPAN was used to transmit near-real time data from the Goddard Space Flight Center (GSFC) to several investigator remote institutions (see Green and King, 1986 and Sanderson et. al, 1986). At the remote institutions, the data was processed and returned (mostly in graphics form) to the encounter room at GSFC for scientific interpretation. In a similar way, SPAN can be used to support many ISTP functions in coordination with the project-dedicated network discussed here.

III. COMMUNICATION REQUIREMENTS

In brief, an ISTP network should fully support electronic mail, log-ins to remote computer sites, the transfer of ASCII (text) files, and the transfer of binary data and graphics files.

The importance of rapid and reliable electronic mail communications between investigators working on a given instrument and with project officials during instrument development, instrument integration, prelaunch testing, and postlaunch data analysis is self-evident. Remote log-ins will allow immediate access, by those appropriately authorized, to access remotely stored calibration and flight data. The transfer of text files will allow an easy and timely exchange, editing, and distribution of needed documents; e.g., technical specifications, project-generated requirements and notices, prelaunch instrument descriptions, and postlaunch data analysis papers. Finally, the transfer of binary data and graphics files (see Gallagher et al., 1985) allows remote testing and control of instrument operations, and analysis of instrument checkout data by programs running on remote machines. Binary data transfers also facilitate the rapid exchange of high resolution space flight measurements and plots among cooperating investigators and in support of agreed-upon collaborative studies.

Of special relevance to the ISTP program, will be the NSSDC central online archive of "key parameter" data for the various planned ISTP spacecraft (as determined by the ISTP/NSSDC Project Data Management Plan in preparation). An electronic network allows investigators to easily tap this resource, either to generate plots directly on NSSDC computers for display at their local facilities or to electronically identify and transfer such key parameter data from NSSDC to their local facilities for local access and display. The NSSDC will also archive and distribute ISTP "event data." Here again, the existence of a network will greatly enhance the accessibility and utility of the ISTP data for the entire space plasma physics science community.

IV. CURRENT SPAN CONFIGURATION

The SPAN network is now a major user of NASA's Program Support Communications (PSC) "highway." The PSC highway allows for large bandwidth cross-country communication lines between NASA centers. These lines form the backbone of the SPAN network.

The newly designed SPAN topology is shown in Figure 1. This topology features four primary routing centers: Goddard Space Flight Center (GSFC), Johnson Space Center (JSC), the Jet Propulsion Laboratory (JPL), and Marshall Space Flight Center (MSFC). Located at each routing center are one or more dedicated computer systems used solely for supporting network communication. These machines are known as DECnet Router Servers or by their DEC designation, DECSA.

Each DECnet router server is connected to the other three routers via 56 kbps dedicated circuits, forming the SPAN DECnet "backbone." The "tail circuits" then complete SPAN by connecting the various SPAN member institutions located around the country into the backbone. These tail circuits, in almost all cases, are simple dedicated leased lines at a minimum of 9.6 kbps running from the member institution to the nearest SPAN primary center.

The new four-router SPAN topology is advantageous for a number of reasons. First, the dedicated routers are separate from any general purpose host machines at the primary routing centers, although they are connected via local networks to other machines at these centers. Thus the network is not vulnerable to many of the kinds of system problems traditionally associated with large, general purpose machines. The new topology has fewer single-point equipment failure locations than other topologies, deletes unwanted traffic over the network backbone, has alternate routing capability built into the backbone structure and enhances maintainability. This topology provides institutions with requirements that cannot be met with a 9.6 kbps tail circuit the option to apply to have the circuit speed upgraded to 19.2 or even 56 kbps to the router location. If the backbone speeds are too low to support network traffic and if additional router line connections have been preinstalled, supplementary high speed backbone lines can be created on demand by the PSC Network Control Center (NCC) at MSFC. If there are more institutions that wish to join SPAN, all that is required are additional tail cicuits to the new remote institutions and additional router capacity at the closest routing centers.

SPAN is further connected to the European Space Operations Centre (ESOC) in Germany using a dedicated 9.6 kbps trans-Atlantic circuit and as a backup can use the X.25 public packet switched networks (TELENET and DATEXP) as the "highway" (with full function DECnet). The international public network

SPAN X.25 connection first passes through the NASA Packet Switch System (NPSS) and then into the GTE public network, TELENET. Once on TELENET, a transparent connection can be made across the Atlantic to the European public network, DATEXP, and finally down into ESOC and the evolving European science network that it is creating. This public network option will remain as a backup connection to the recently installed dedicated circuits. A SPAN link to Japan through their public network,Venus-P, done in a similar manner to the public network connection to Europe, is now under study by the NSSDC for the Geotail/ISTP project (Green et al., 1987).

V. PROPOSED ISTP NETWORK COMMUNICATIONS MODEL

Network traffic associated with a project of the scope of ISTP may well exceed the capacity of the current SPAN. A network is essential to realizing the full potential for ISTP science and, as such, logically should be a resource that can be sized and controlled directly by the project and the ISTP scientific community. From these considerations, it is proposed here that an ISTP dedicated network should exist and be interconnected with the existing SPAN system.

Figures 2 through 5 illustrate the proposed configuration. The project would be responsible for four additional DECnet Router Servers, one to be placed at each of the existing SPAN centers and configured effectively in a star, with the GSFC/CDHF router at the center as shown in Figure 2. These routers would be connected by three 56 kbps circuits. The circuits would be "dialed up" by the MSFC Network Control Center (NCC) only during the regular working day or to serve periods of high ISTP activity.

The relationship between the proposed ISTP network and SPAN is shown in Figure 3. The SPAN and ISTP backbone communication links run parallel to one another. This construction would provide a dedicated ISTP network and yet would completely connect with SPAN, its associated remote nodes, and its international connections.

At each of the SPAN routing centers, the ISTP routers would be connected to the SPAN routers by a local area Ethernet (as shown Figures 4 and 5). ISTP may only need to use the project network backbone during the day. At night or in the event of any ISTP circuit failure, the SPAN backbone circuits would be automatically available as substitute or backup. The NCC would also be able to dynamically create additional circuits on demand if needed by the ISTP network (if the required router lines had been installed).

Existing tail circuits to ISTP Principal Investigators (PI) and any desired Co-investigators (Co-I) could be moved from the existing SPAN routers to the ISTP routers. Some care would be required in address assignments in the combined system and some load balancing considerations might also apply to specific tail circuit connections. Other Co-Is would remain connected to SPAN at no direct cost to the project but with full, if possibly somewhat slower, access to the full ISTP network. When the ISTP circuits are active, ISTP traffic between the PI groups would move over that network. At night, the ISTP routers would send that traffic to the connected SPAN router and then out over the SPAN network, back to the ISTP router at another center, and out over the appropriate tail circuit. ISTP investigators would have full SPAN access to all institutions on SPAN at any time. As the ISTP project phases down and communication requirements decrease, the ISTP daytime 56 kbps lines would be replaced by communications through the router connections to SPAN.

The network connection to ISAS would be located at JPL as shown in Figure 4. The routing center configuration at GSFC would be considerably different from the other routing centers and is shown in Figure 5. The ISTP router would be attached to the CDHF and joined to the SPAN router at NSSDC via a local dedicated 1 Mbps line within GSFC.

Note that overall ISTP data and system security can be managed with several specific DEC software options. Data that are resident on ISTP disks can be protected on a per file basis; i.e., by locking against access by other users using the VMS SET PROTECTION command. Users can also software lock entire accounts via the VMS AUTHORIZE utility to prevent network access of any sort.

The advantages of this proposed model for an ISTP network are numerous.

1. ISTP has a dedicated network when it needs it. SPAN can provide the backbone of the network for use in the several years before launch without burdening the project with expensive communications capabilities that are used infrequently.

2. SPAN provides a backup to the ISTP network and substitutes for the ISTP line configuration at night or during hours of low traffic.

3. ISTP gets full interconnection to all SPAN users.

4. ISTP can use the existing SPAN management structure but retains full control over its own network.

5. ISTP project costs are minimized by coordination with existing SPAN management and hardware facilities.

6. The ISTP project can upgrade any its tail circuits or backbone when traffic warrants.

7. ISTP PIs will be fully coupled to NSSDC and to all Co-Is and other institutions in the United States, Europe, and Japan that are connected to SPAN.

8. The network can be gracefully turned back to SPAN as the project phases down, providing continued scientific support but with no continuing costs.

9. An ISAS link is only needed to JPL and not GSFC, thus saving the project the cost of an extra coast-to-coast link.

VI. REQUIPMENT AND OPERATIONAL COSTS

The ISTP project should support the following:

1. Four DECnet Router Servers, appropriate software, and maintenance for the hardware and software.
2. Three 56 kbps lines, up only during the day and during special periods of the ISTP mission as required.
3. One 1 Mbps local line to connect the ISTP router at the CDHF to the NSSDC and SPAN.

The NSSDC should be responsible for the following:

1. Management of SPAN as discussed in the document "Management of the Space Physics Analysis Network" (see Green et al., 1986).
2. Maintenance of SPAN at a level of at least 95% availability.
3. Operation of a SPAN network information center.
4. Availability of all relevant NSSDC facilities, data archives, and documentation to all ISTP investigators.
5. Provision of SPAN links to all approved ISTP co-Investigators.

VII. SUMMARY AND CONCLUSIONS

This proposal constitutes a cost-effective and fully functional model for an ISTP network. This model builds on a large body of accumulated experience and utilizes the existing SPAN system, while allowing the project full control over its own network and the capabilities associated with it. It uses a proven software configuration and provides maximum interconnection, where needed and desired, to a wide space science community not only in the United States but in Europe and Japan as well.

LIST OF ACRONYMS

ASCII	- American Standard Code for Information Interchange
CDHF	- Central Data Handeling Facility at GSFC
CoI	- Co-Investigator
DATEXP	- A PPSN in Germany
DEC	- Digital Equipment Corporation
DECnet	- DEC networking products generic family name
ESA	- European Space Agency
ESOC	- European Space Operations Center
ESTEC	- European Space Research and Technology Center
GSFC	- Goddard Space Flight Center
ISAS	- Institute of Space and Astronautical Science (Japan)
ISTP	- International Solar Terrestrial Physics
JPL	- Jet Propulsion Laboratory
JSC	- Johnson Space Center
kbps	- Kilobits per second
Mbps	- Megabits per second
MSFC	- Marshall Space Flight Center
NASA	- National Aeronautics and Space Administration (US)
NCC	- Network Control Center at MSFC
NPSS	- NASA Packet Switched System (using X.25 protocol)
NSSDC	- National Space Science Data Center (at GSFC)
PI	- Principal Investigator
PPSN	- Public Packet Switched Network
PSC	- Program Support Communications
PSI-J	- The DEC Packetnet System Interface for Japan
SPAN	- Space Physics Analysis Network
TELENET	- A PPSN owned by GTE in the United States
Venus-P	- A PPSN in Japan
X.25	- A "level II" communication protocol for packet switched networks

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Figure 1 - The current backbone configuration of SPAN is made up of four routing centers (GSFC, MSFC, JPL, and JSC) connected together by 56 kbps dedicated lines. The SPAN tail circuits are 9.6 kbps lines from the remote institutions to the closest routing center.

SPAN Backbone Configuration

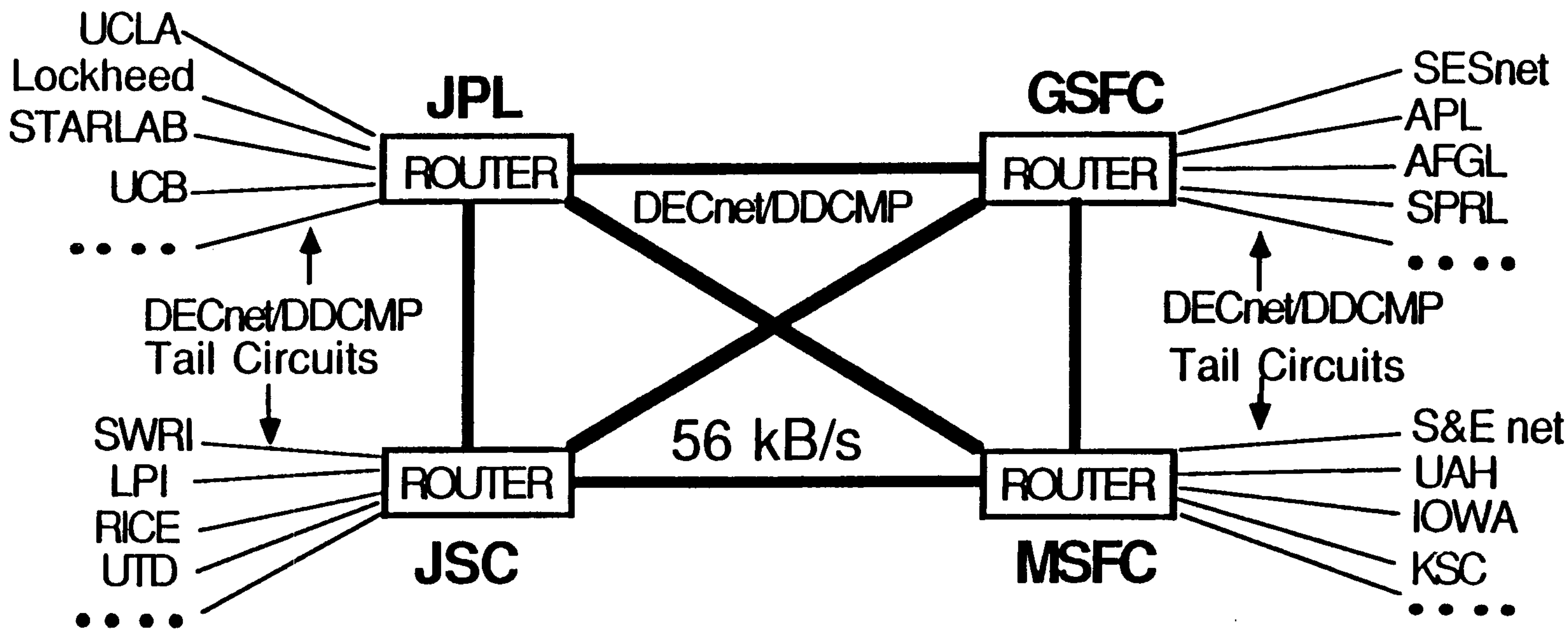

FIGURE 1

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Figure 2 - The proposed ISTP backbone and tail circuit network. Note that this system of lines utilizes the existing SPAN routing centers.

MISSION NETWORK CONFIGURATION

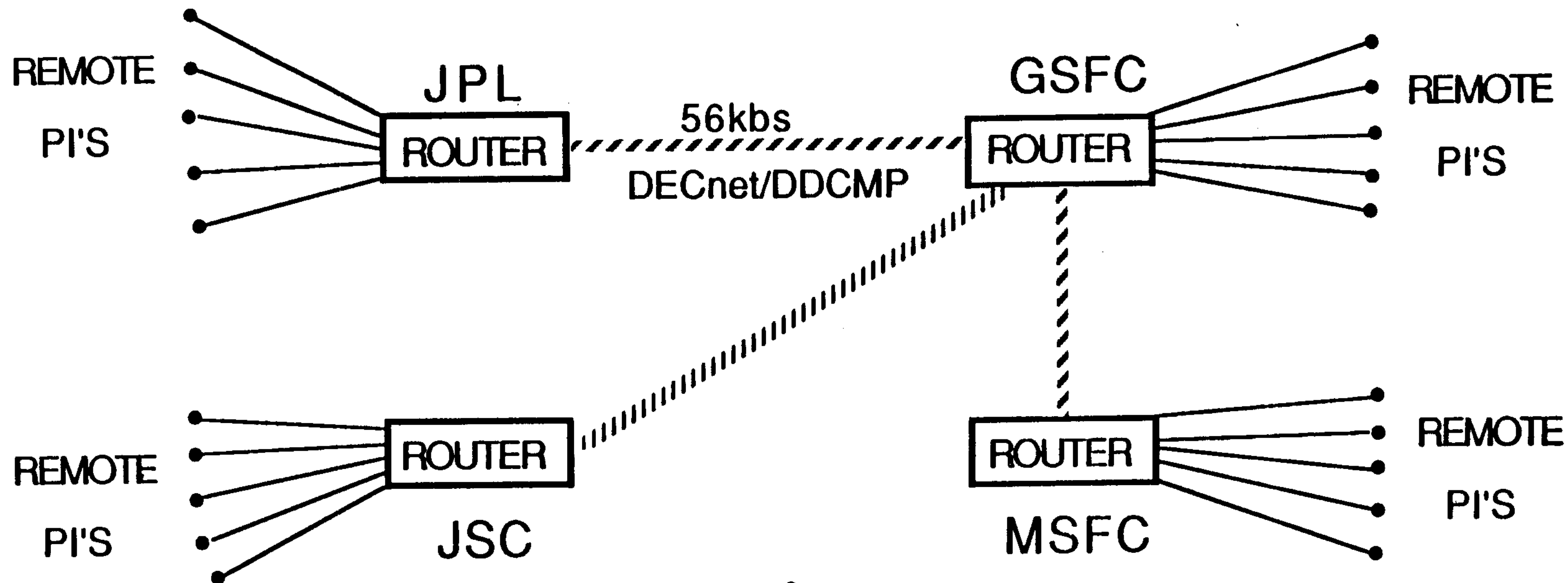

FIGURE 2

Figure 3 - The configuration of SPAN and the ISTP network is shown to illustrate the parallel nature of these two system. With this configuration, the ISTP network would be maintained as a dedicated system for ISTP principal investigators and SPAN would carry ISTP auxiliary traffic, with nearly all the ISTP co-investigators already attached to tail circuits. With these two systems configured in this manner, a major cost savings can result because the ISTP backbone can be easily disconnected at night or during times of low usage. During these times the network configuration returns to that originally given by SPAN.

SPAN AND MISSION BACKBONE CONFIGURATION

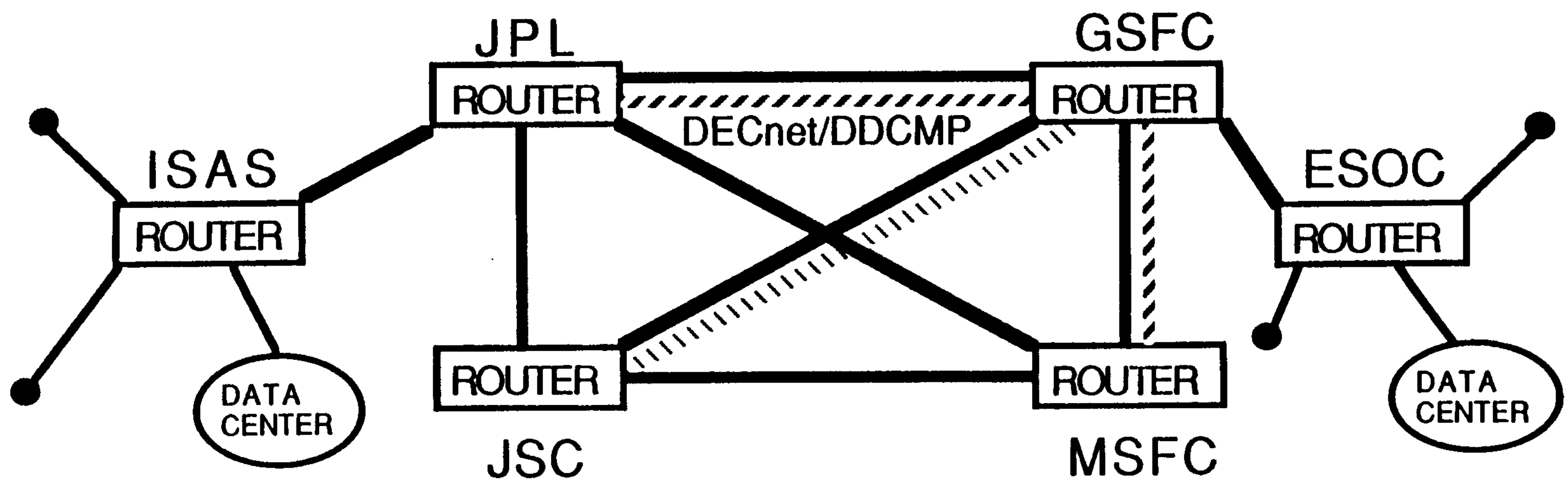

FIGURE 3

56kb/s LINES

MISSION

SPAN

Figure 4 - The detailed configuration of the JPL routing center. At the routing center both the SPAN and ISTP routers are connected to the same Ethernet and have complete interconnection.

NETWORK CONFIGURATION AT REMOTE ROUTING CENTER

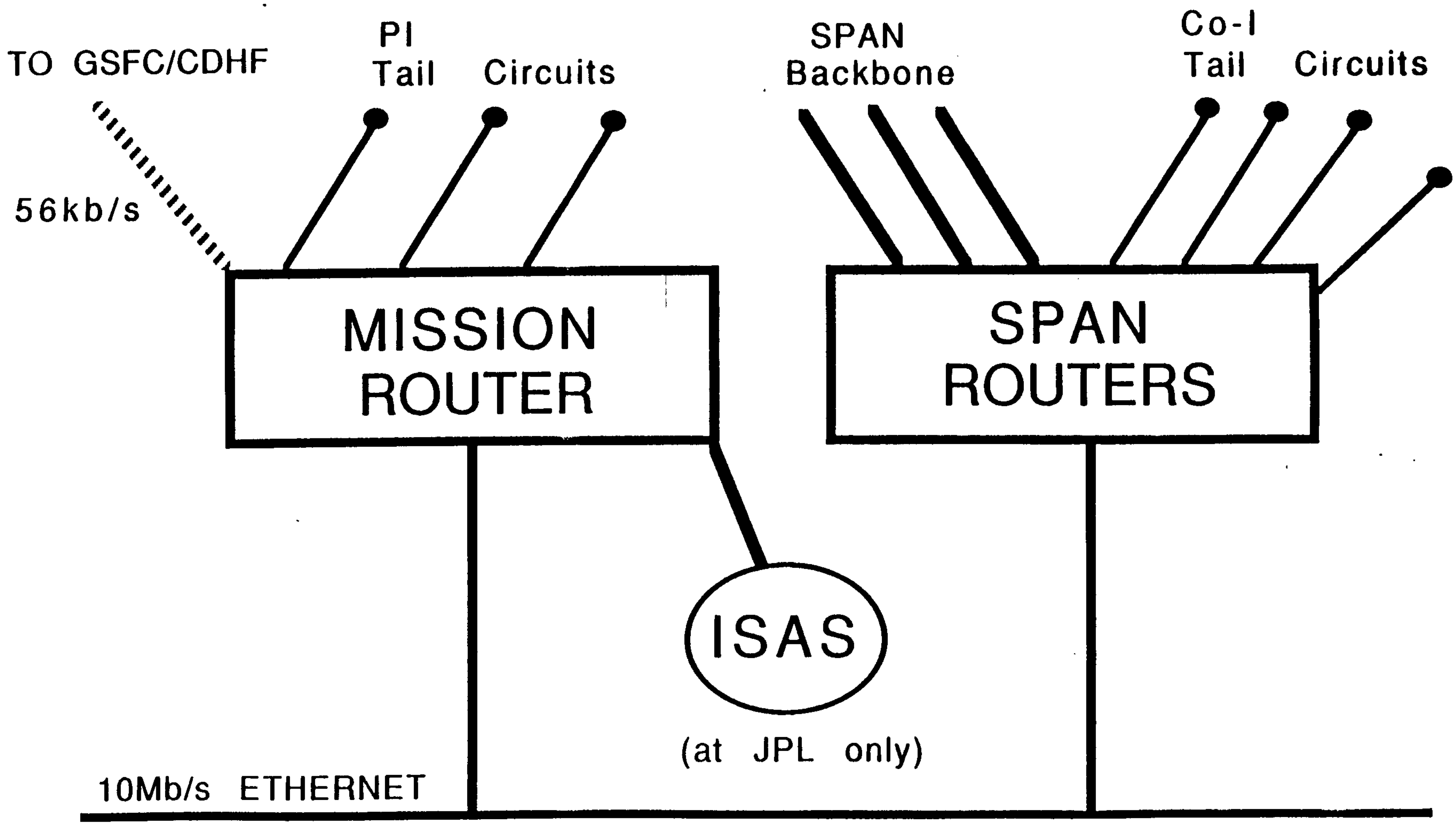

FIGURE 4

Figure 5 - The configuration of the SPAN routing center at the NSSDC and the ISTP routing center at the GSFC/CDHF. A line of at least 1 Mbps directly connects these two systems and enables investigators and co-investigators access to the CDHF and NSSDC facilities. In addition, the direct local connection facilitates the movement of mission-specific information (such as key parameters) from the CDHF to the NSSDC archives.

NETWORK CONFIGURATION AT GSFC

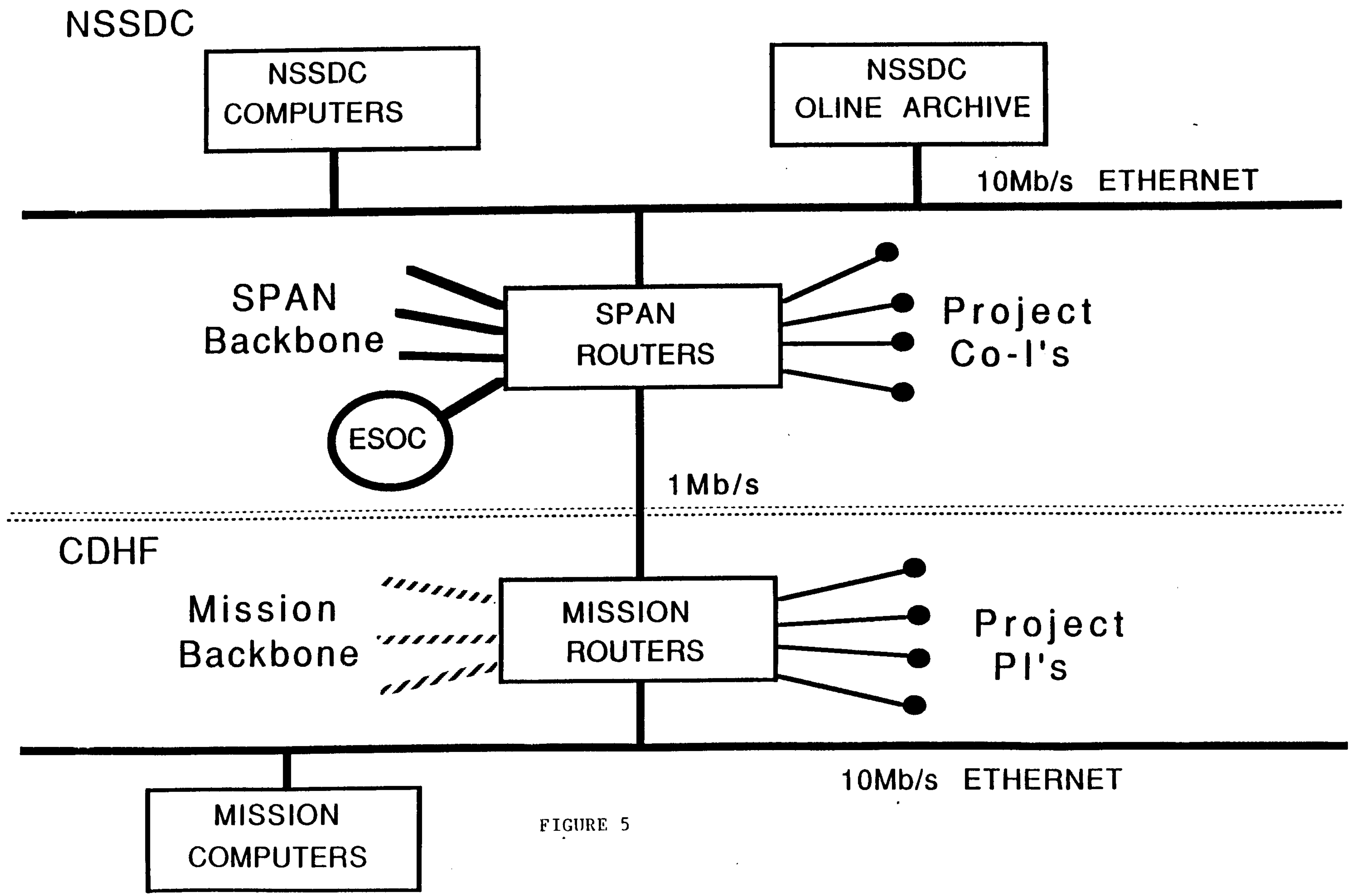

FIGURE 5